



DUGESIANA

Revista de Entomología



Volumen 31 número 2

ISSN 2007-9133



Dugesiana, Año 31, No. 2, (julio-diciembre, segundo semestre 2024), es una publicación semestral, editada por la Universidad de Guadalajara, a través del Centro de Estudios en Zoología, por el Centro Universitario de Ciencias Biológicas y Agropecuarias. Camino Ramón Padilla Sánchez # 2100, Nextipac, Zapopan, Jalisco, Tel. 3337771150 ext. 33218, <http://dugesiana.cucba.udg.mx/index.php/DUG>, glenusmx@gmail.com. Editor responsable: José Luis Navarrete-Heredia. Reserva de Derechos al Uso Exclusivo 04-2009-062310115100-203, ISSN: 2007-9133, otorgados por el Instituto Nacional del Derecho de Autor. Responsable de la última actualización de este número: José Luis Navarrete-Heredia, Editor y Ana Laura González-Hernández, Asistente Editorial. Fecha de la última modificación 1 de julio 2024.

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The marine littoral *Spinactaletes* (Collembola: Actaletidae) from Mexico, redescription of *S. boneti* and new records

El género litoral marino *Spinactaletes* (Collembola: Actaletidae) en México, redescipción de *S. boneti* y nuevos registros

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ABSTRACT

A morphological study of *S. boneti* (Parisi, 1972) and its intraspecific variation is presented, providing a complete description with drawings, and photos. New records for this and other species are given.

Key words: Morphology, Pacific coast, Baja California, Veracruz, distribution.

RESUMEN

Se hizo un estudio de la morfología de *S. boneti* (Parisi, 1972) y su variación, incluyendo una descripción detallada completa con dibujos y fotos. Se dan nuevos registros para esta y otras especies.

Palabras clave: Morfología, costa pacífica, Baja California, Veracruz, distribución.

Aquatic Collembola from Mexico was recently summarized (Palacios-Vargas 2023). A total of 14 families, 18 genera and 78 species are known, counting those of fresh water and marine littoral, including the Actaletidae which is rare and strictly marine littoral. This small family of springtails was revised by Soto-Adames (1988), who erected the genus *Spinactaletes* for species living in Mexico and Caribe, which have sexual dimorphism and dental spines, and leaving the only species of *Actaletes*, *A. neptuni*, as monogeneric species of the family in Europe.

The first species in the Americas of this group was described by Parisi (1972) from Mexican Pacific (Acapulco) as a member of *Actaletes*. The description of this species was very brief and after synonymized by Soto-Adames (1988) as *Spinactales boneti* (Parisi, 1972); he detected important morphological variation which can make presume that there are several species. The second, *A. calcarius*, was described by Bellinger (1962) from Jamaica, which also differs from *A. neptuni* Giard, 1889 in having a remarkable sexual dimorphism characterized by the presence of one spur on tibiotarsus III in male adults. Glynn (1968) found in Puerto Rico (Guánica) specimens of *Spinactaletes* associated with *Acanthopleura* (Polyplacophora: Mollusca) and noted that it is attracted by the vegetal debris produced by these mollusks. In 1972 *A. venezuelensis* Najt y Rapoport was described from mangrove roots in Venezuela (Chiriviche).

Most recent taxonomical contributions were done by Soto-Adames (1988) and Soto-Adames and Soto-Adames y Gillén

(2011) who described several species and gave complements to others previously known and provided a key for 11 valid species known today, but in one previous contribution Soto-Adames (2002) recorded one species from US Virgin Islands, and gave some molecular information.

Several studies have been done about *S. boneti*, as the structure of the epicuticle, by Dallai and Malatesta (1973), it was included in the revision of the family by Soto-Adames (1988) who made additions to the knowledge of the morphology. More recently Nunes Godeiro, et al. (2022) gave the complete mitochondrial genome of this Mexican marine littoral species and discussed its phylogenetic placement, suggesting its position as a sister group of the remaining Entomobryomorpha species with moderate bootstrap support (68%). Those results agree with the study made by D'Haese (2003) who concluded that the springtails had a terrestrial edaphic origin with the semi-aquatic life representing a secondary specialization, not a primitive condition.

Palacios-Vargas y Castaño-Meneses (2009) discussed the sexual dimorphism in several families and genera, highlighting that, the strongest sexual dimorphism is found in families and genera which have aquatic habitats; species belonging to primarily aquatic families (fresh water or marine water) have the most evolved morphology, where males have clasping antennae to attach the females during sexual courtship. Most species of *Spinactaletes* have males with tibiotarsal spur (except *S. nemyops*), and some of them, including *S. boneti*, *S. campylorachis* and *S. calcalectoris*,

have spines on femur I and tibiotarsus I.

Abbreviations used in this contribution are: Ant. (antennal segment), OPA (postantennal organ), Pls (postlabial setae), bm (basomedial setae), Tita (tibiotarsus).

Spinactaletes boneti (Parisi, 1972)
(Figs. 1-10)

Redescription. Largest female 1.4 mm (n=7) (Fig. 1A, C), largest male 1.2 mm (n=1) (Fig. 1B, D). Antennae, head, trunk, and legs uniformly dark grey (Fig. 1A y B); manubrium and basal half of dens light grey, distal half of dens white. Proportion of Ant. I-IV for males as 1:1; 2.6;2.5; 1.6 and females as 1:1.9; 2; 1.8; 1.5. Antennae of males significantly longer (0.78 mm) than in females (0.59) (Figs. 1C, D); average proportion of total antennal length/dens 3.2 in males and females. Ant. IV rectangular, apically weakly truncate with 8 dorsal sensilla (Fig. 2A, 3A) and one big ventral curving seta; apex with about 11 truncate sensilla (Fig. 2B). Ant. III (Fig. 2C) ventrally with 1 smooth spine, 4 long posterior setae and 5 thin, trichobothria-like setae (Fig. 2C, 3B); 5 sensilla on distal part of article, sense organ with two fungiform sensilla (Fig. 2C), under a low cuticular fold. Apex of Ant. III with a lateral cuticular tubercle. Ventral face of Ant. II (Fig. 2D) with setae acuminate and no spine-like seta; longest dorsal setae on Ant. II on lateral margin (Fig. 2D, 3B). Ant. I with many setae and ventrally with a concave surface and one small tubercle with two tiny spines (Fig. 2D, 3C).

Head with many smooth setae (Fig. 4A), 8+8 eyes, OPA about two times the size of one eye (Fig. 3D, 4A). Interocular setae with 9–11 setae (Fig. 3D, 4A). Labrum with 4/4,5,4 setae (Fig. 4B). Posterior to prelabral setae, with two spines (Fig. 4B). Mandibles big and strong, two big basal teeth, molar surface well developed, each element seems like a cauliflower (Fig. 5A), and 4 apical teeth (Fig. 5B). Maxilla with a strong capitulum and six lamellae. Labium with 5 proximal setae, only 4 basomedial setae (Fig. 4 C) and a full complement of papillae (Figs. 5C, E). Papilla C isolated from others, A and B close together but not fused, D and E partially fused at base; apical seta on papilla D longest, apical seta on papilla B shortest; hypostoma with many strong long setae on each side (Fig. 5D). Papilla A with 1 guard seta, papillae B and D each with 4 setae, papilla E with 6 setae (Fig. 5C). Post labium with 1 + 1 seta along cephalic groove (Fig. 4C).

External surface of femur I with 2 spines inserted close together near base of segment (Fig. 6A), proximal spine 25 x 4 μ m tapering, distal spine 25 x 5 acuminate; and two distal spines, first acuminate and the last tapering. Internal surface of Tita I, with 2 large spines, proximal, 30 x 4 μ m, tapering; distal 35 x 4 acuminate (Fig. 6B); tibiotarsus of males longer than in females, proportion Tita I /dens 0.52 males, 0.37 in females. Tita on all legs with an apical subdivision with 6 setae (Fig. 6C, D). Tita III of male, with sclerotized process of tibiotarsal spur cylindrical, long (Figs. 6C, 7D), with 5 seta, distal two longer and stronger than

others, as long as sclerotized process, which ends in one piece (Fig. 7E) or with four teeth on one side (Fig. 9A). Females with ventral chaetotaxy of Tita III with seta w2 subequal to w4 (Fig 6D). Tita I-III in female 150, 170; 230 μ m; Tita I-III in male = 150, 170; 240 μ m.

Pretarsus with one small setae on each side (Fig. 7A), unguis with one internal tooth (Fig. 7B), unguiculus without teeth, almost straight (Fig. 7C). Tenent hair is leaf-shaped and covers most of dorsal surface of unguis (Fig. 7A, 7C). Ventral tube with only 3 + 3 setae (Fig. 5F). Retinaculum with 4 teeth on each ramus and corpus with 2 anterior setae and 3 longer posterior setae (Fig. 6E).

Abdomen with four pairs of bothriothrica (Fig. 4D), last three segments fused. The furcula articulates with two parts of basal sclerites, and two pairs of rod-shaped, sclerotizations. The inner pair is longer than the external, tapering and extending to forward the length of Abd. IV, the external pair is shorter but thicker and knobbed at the anterior end (Fig. 4 D).

Manubrium almost as long as dens, with 80 setae on posterior surface (Fig. 8A) and 66 on anterior surface (Fig. 8B). Anterior part of manubrium with three columns of middle setae, distal setae thicker and longer than others (Fig. 8B). Dens, basal part with 4 dorsal spines, the proximal bigger than others (Fig. 7E, 8C); distal part of dens dorsally with 3 internal spines and 6 external, and 7 long setae on internal side (Fig. 8C). Juveniles with a smaller number of spines and long setae. Mucro with apical tooth and two lamellae (Fig. 7G). Genital opening on extreme posterior surface of abdomen. Female genital plate with one pair of setae (Fig. 9B); male opening is complex and difficult to interpret (Fig. 9C, D), as pointed out by Bellinger (1962) in *S. calcarius*. We observed in *S. boneti* the presence of some paired lamellae with fine internal teeth (Fig. 9C).

Remarks. - Since the description of *S. boneti* Parisi (1972), the author notes the sexual dimorphism, the males have tibiotarsal spur which are slender than *S. calcarius* (Bellinger, 1962) (Figs. 10 A, B, C, D), and it has spines on femur and Tita I, the elongation of antenna and other structures. Parisi (1972) also noted the presence of spines on dens, a reason why Soto-Adames created the genus *Spinactaletes*, to include the species from Mexico and Caribe. The presence of 9 spines on femur I, described by Parisi, was explained by Soto-Adames (1988) as a variation in old males.

Variation. Soto-Adames (1988) in his redescription of *S. boneti* says that the total length of the body is from 0.7 to 0.9 mm. He found that one specimen had only 4 labral setae on row m. One male from Acapulco had only one sensillum in the apex of Ant. III. One specimen has only 2 + 3 setae on ventral tube. Another specimen had 2/1/3 tenacular setae (six, the number is 5). The spines of distal part of dents varies from 5-2 to 3-6.

As Bellinger (1962) indicates in his description of *S. calcarius*, we can observe also in *S. boneti*, that the furcula articulates with two dorsolateral, rod-shaped, tapering scler-

rotifications (Fig. 8C). It seems that *Spinactaletes* has developed strongest jumping apparatus than other springtails, because they must deal with the sea waves. This structure was observed and briefly described by Bellinger (1962) in *S. calcarius*.

The jumping apparatus of *Spinactaletes boneti* (Actaletidae) shares with that of *Orchesella cincta* (Entomobryidae) some of the structures cited by Oliveira (2022), as the BS2 (basal sclerite 2), BS3 (basal sclerite 3), and BR (basal rod) as shown in Fig. 4D which extends anteriorly to the fourth abdominal segment. This apparatus deserves special study to know all the muscles involved.

New records

Spinactaletes boneti (Parisi, 1972).

MEXICO. Guerrero: Marquelia: Las Peñitas beach. 16° 34' 60" N; 98° 49' 0" W; ex littoral marine sand. February and April of 2013, José G. Palacios-Vargas, 3 specimens, ex sand from the beach. J. G. Palacios-Vargas col. FC-UNAM: LESM-AC: QL05955, 6 and 5966.

MEXICO: Baja California Sur: Ensenada de Muertos. 10 specimens under slides and several in alcohol, 15-XI-1987, J. G. Palacios y M. Vázquez cols. They were cited as *Actaletes* sp. by Vázquez et Palacios-Vargas, 1990, but they belong to *S. boneti*.

This species is very wide distributed in the Pacific Ocean, in Mexico, along the states of Guerrero, Nayarit, Sonora and Baja California Sur (La Paz and Coronados Island) and probably in most islands of the Mexican California Gulf and maybe arrives to Costa Rica, where Soto-Adames and Guillén (2011) found a supposed new species, but did not found males and they say that perhaps: "the population from Mal País is co-specific with the Mexican species"

Distribution reported from Soto-Adames (1988) is the Pacific coast, from Zihuatanejo to Acapulco. We have increased the distribution to Sinaloa, Baja California Sur and Puerto Vallarta (Fig. 11).

Spinactaletes calcarius (Soto-Adames, 1988)

MEXICO: Veracruz. Montepío, 18°64' 16"N, 95°09' 47". 00 m asl, 14 specimens, ex algae on stones surpassing the water of sea. 24-VII-1988, J. G. Palacios-Vargas col. Cited as *Spinactaletes ca. calcarius* by Palacios-Vargas (2003), from stones with algae in the beach Montepío.

Spinactaletes nemyops (Soto Adames, 1988)

Spinactaletes nemyops (1987) from Sonora, was the same cited as *Actaletes* sp. by Christiansen and Bellinger (1988).

Spinactaletes myoptesimus (Soto Adames, 1988)

UNITED STATES: Virgin Islands. Saint Croix. 17°41'6" N, 64°49'36.16" O. Two specimens, ex stones. 21-II-2024. J. G. Palacios Vargas col.

This species was found on stones along the eastern side of Lindburgh beach on southwestern St. Thomas, but none were seen on rocks in Hull Bay on the northern shore of the island. Soto-Adames (2002) did not find males but states that analysis of mitochondrial DNA sequences shows that this population is almost genetically identical to *S. myoptesimus* from southwestern, Puerto Rico.

ACKNOWLEDGMENTS

Blanca E. Mejía Recamier prepared the microscopic slides for this study; authors thanks Dr. Gerardo Rivas for providing us material from Sinaloa; MS. Jair Páez and MS. Elihú Catalán for making the illustrations, Dr. Silvia Espinosa (Facultad de Ciencias, UNAM) processed the specimens and took the scanning electron microphotos, Dr. Gabriela Santibañez for helping us with the distribution map and Diego Bernal Aquino for carrying out bibliographic research. This contribution is dedicated to Dr. Gabriela Castaño Meneses for her contributions to the study of microarthropods.

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Reibido: 7 mayo 2024

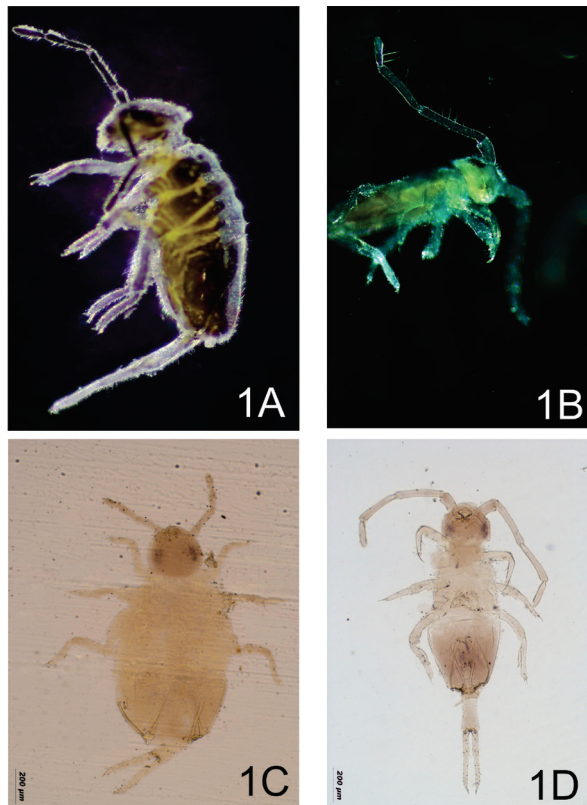
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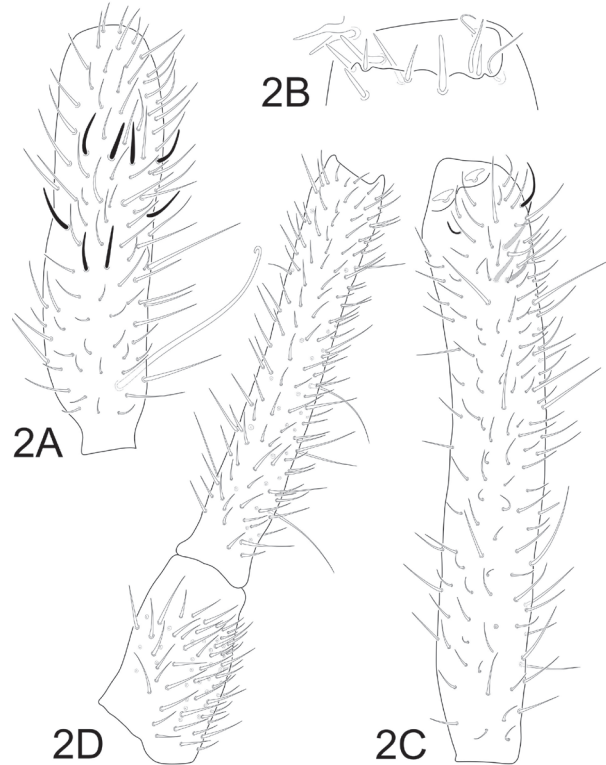
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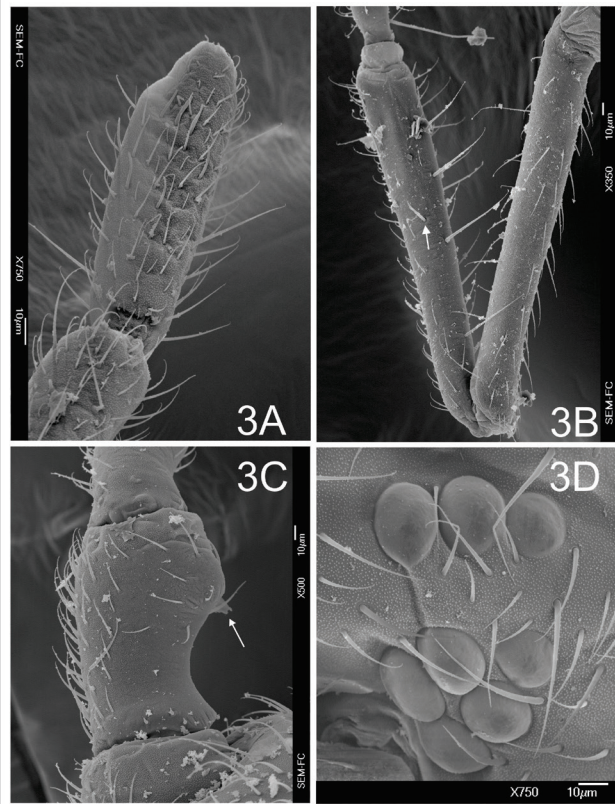
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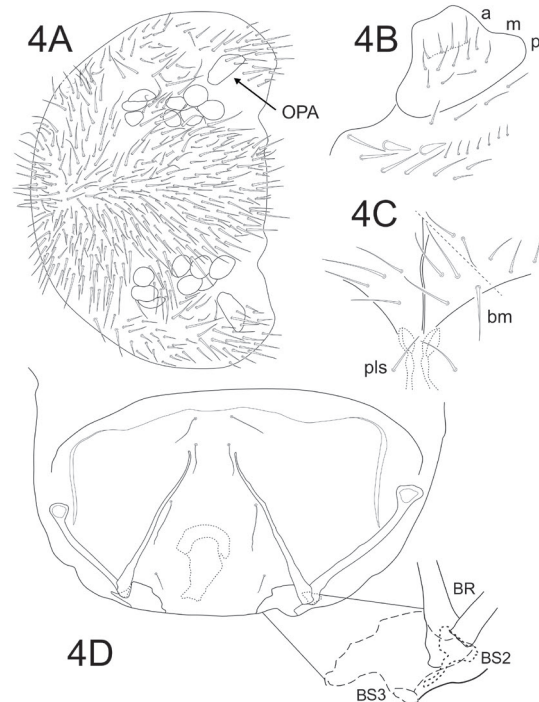
Figures. 1A-D. *Spinactaletes boneti*. A, female in alcohol; B, male in alcohol from Baja California Sur; C, female under slide; D, male under slide from Sinaloa.



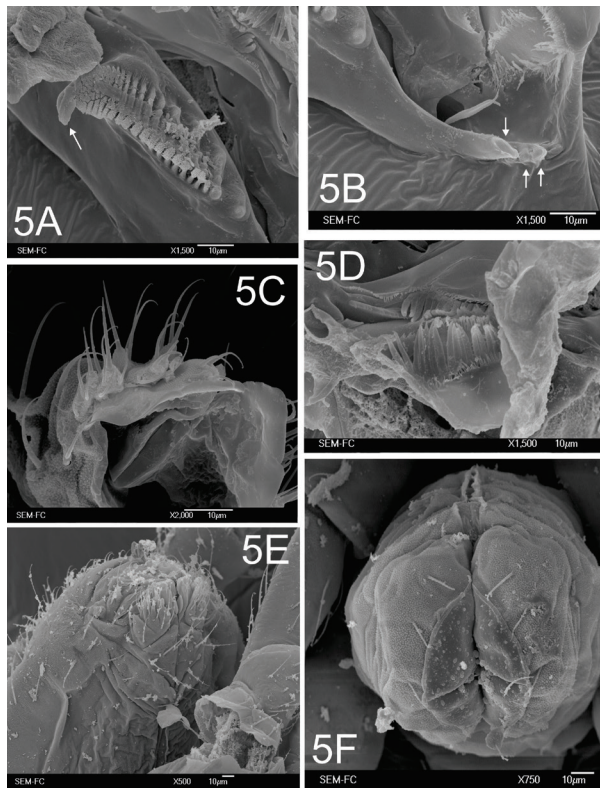
Figures. 2A-D. *Spinactaletes boneti*. A, Ant. IV; B, Apex of Ant. IV; C, Ant. III; D, Ant. I and II of male.



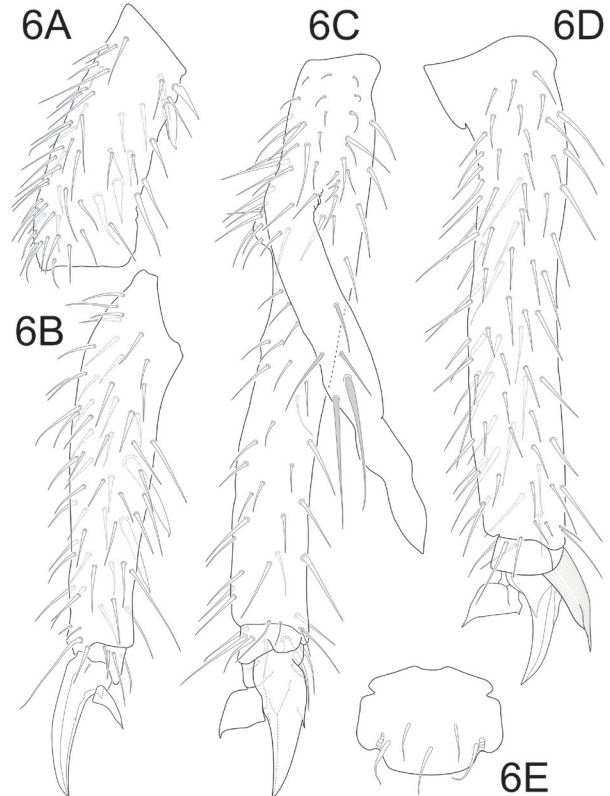
Figures. 3A-D. *Spinactaletes boneti*. A, Ant. IV; B, Ant. II and III; C, Ant. I; D, eyes and interocular setae of male.



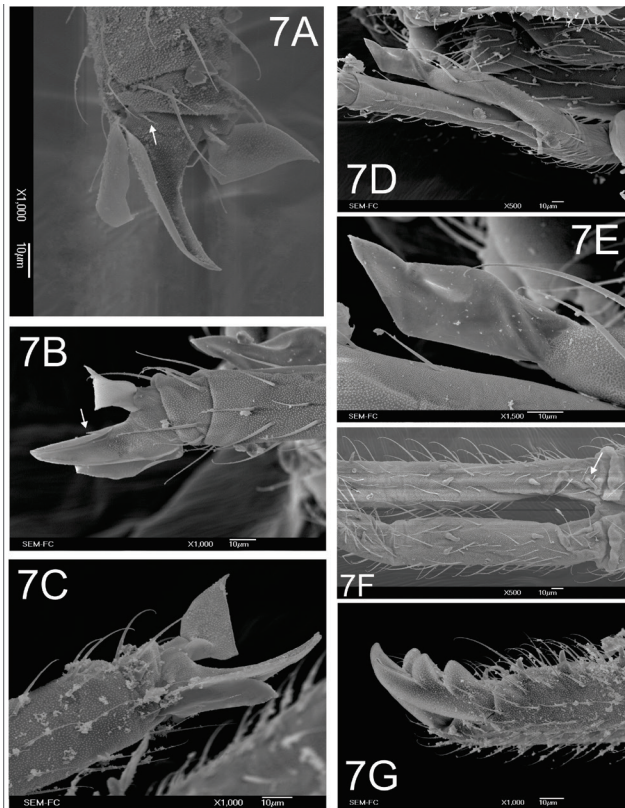
Figures. 4A-D. *Spinactaletes boneti*. A, head chaetotaxy, eyes and OPA; B, labrum, prelabral setae and anterior setae of head; C, postlabial setae, basoposterior setae; and anterior setae of labium. D, Abdomen showing distribution of bothriothriza, genital opening of male and sclerites of jumping apparatus. BR: basal rods; BS2: basal sclerite 2; BS3: basal sclerite 3.



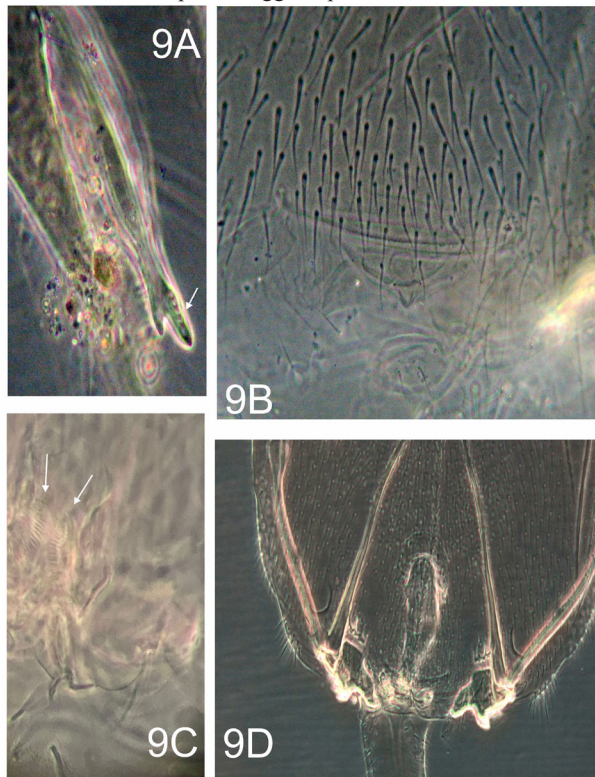
Figures. 5A-F. *Spinactaletes boneti*. A, female mandible showing molar surface; B, apical teeth of mandible lateral view; C, labium from above; D, hypostoma; E, mouth from ventro-lateral view; F, ventral tube.



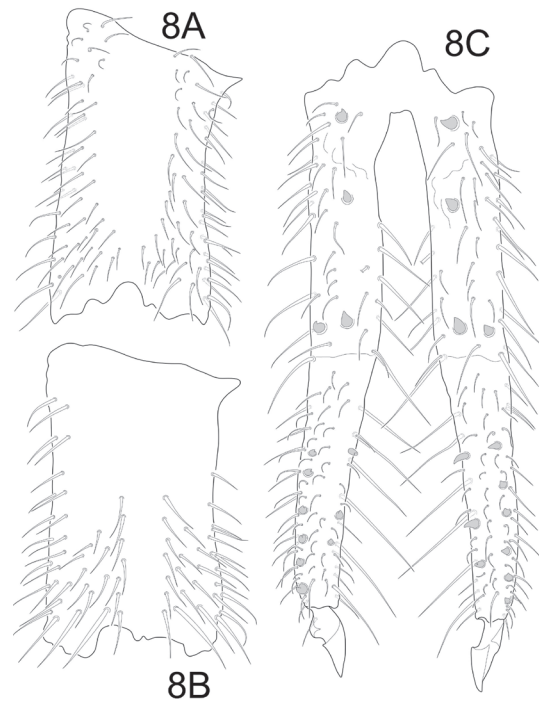
Figures. 6A-E. *Spinactaletes boneti* male; A, Femur I, showing four spines; B, Tita I, with two spines; C, Tita III with male spur; D, female Tita III; E, retinaculum.



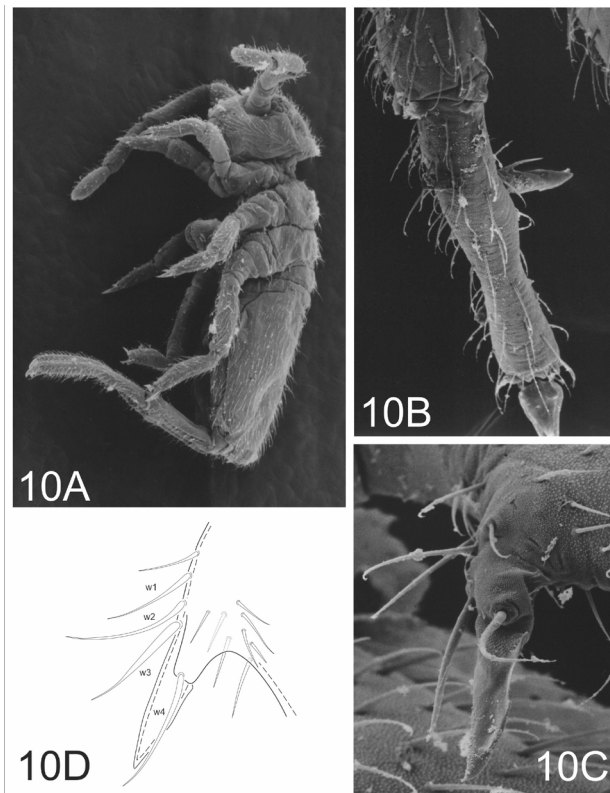
Figures. 7A-G. *Spinactaletes boneti*. A, Ungual complex of Tita I; B, Ungual complex of Tita III; C, Ungual complex of Tita II; D, tibiotarsus III and spur of male; E, Sclerotization of spur; F, basal part of dens, arrow points biggest spines; G, mucro.



Figures. 9A-D. *Spinactaletes boneti*. A, bifid tibiotarsal spur; B, genital plate of female; C, genital plate of male, arrows show denticulate lamella; D, genital area of male.



Figures. 8A-D. *Spinactaletes boneti*. A, dorsal surface of manubrium; B, ventral surface of manubrium; C, anterior part of dens.



Figures. 10 A-D. *Spinactaletes calcarius*. A, female lateral view; B, tibiotarsus III and spur of male; C, approach of a male spur; D, chaetotaxy of male spur.

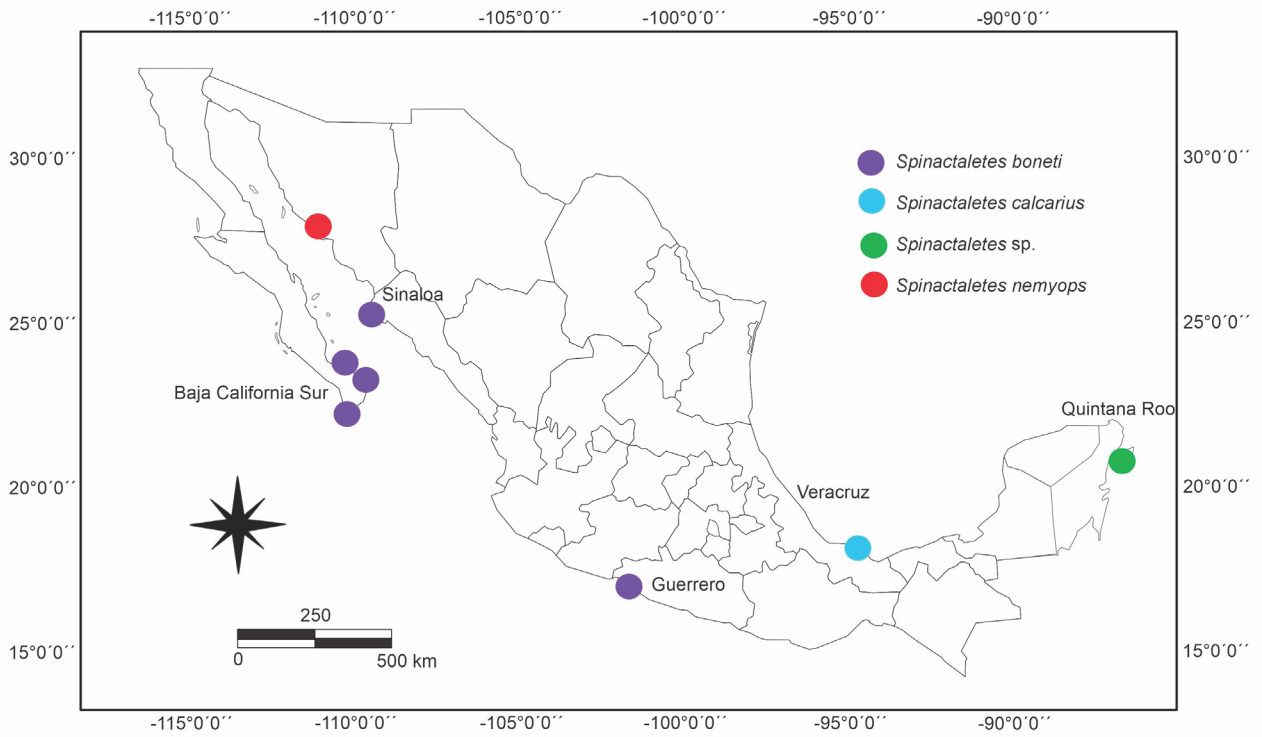


Figure. 11. Map of distribution of Mexican species of *Spinactaletes*.